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INT CL^4 **G01S**

(54) A detector of pulses of electromagnetic radiation, more particularly laser pulses

(57) Sensor means comprise three cylindrical bodies having sensing windows of constant width for all the bodies, or varying according to an exponential law as a function of the bearing angle in the case of the third body (C1). One of the first two bodies (C2) has a skirt masking part of the window, to make this body responsive to the elevation. The light signals available in the three bodies are carried by optical fibres (L11 to L31) of different lengths to a photodetector (PD) connected by a capacitor (CL) to a logarithmic amplifier (AL) followed by an analog/digital coder (CAN) and processing means (DT).

It is then possible to measure the elevation and bearing of an incident laser pulse, its duration and possibly its repetition period.

FIG. 1

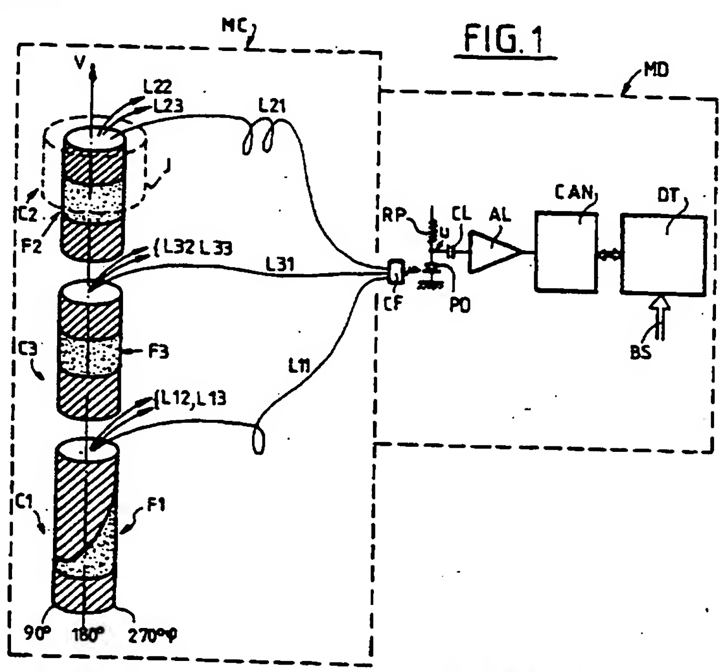

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FIG. 1

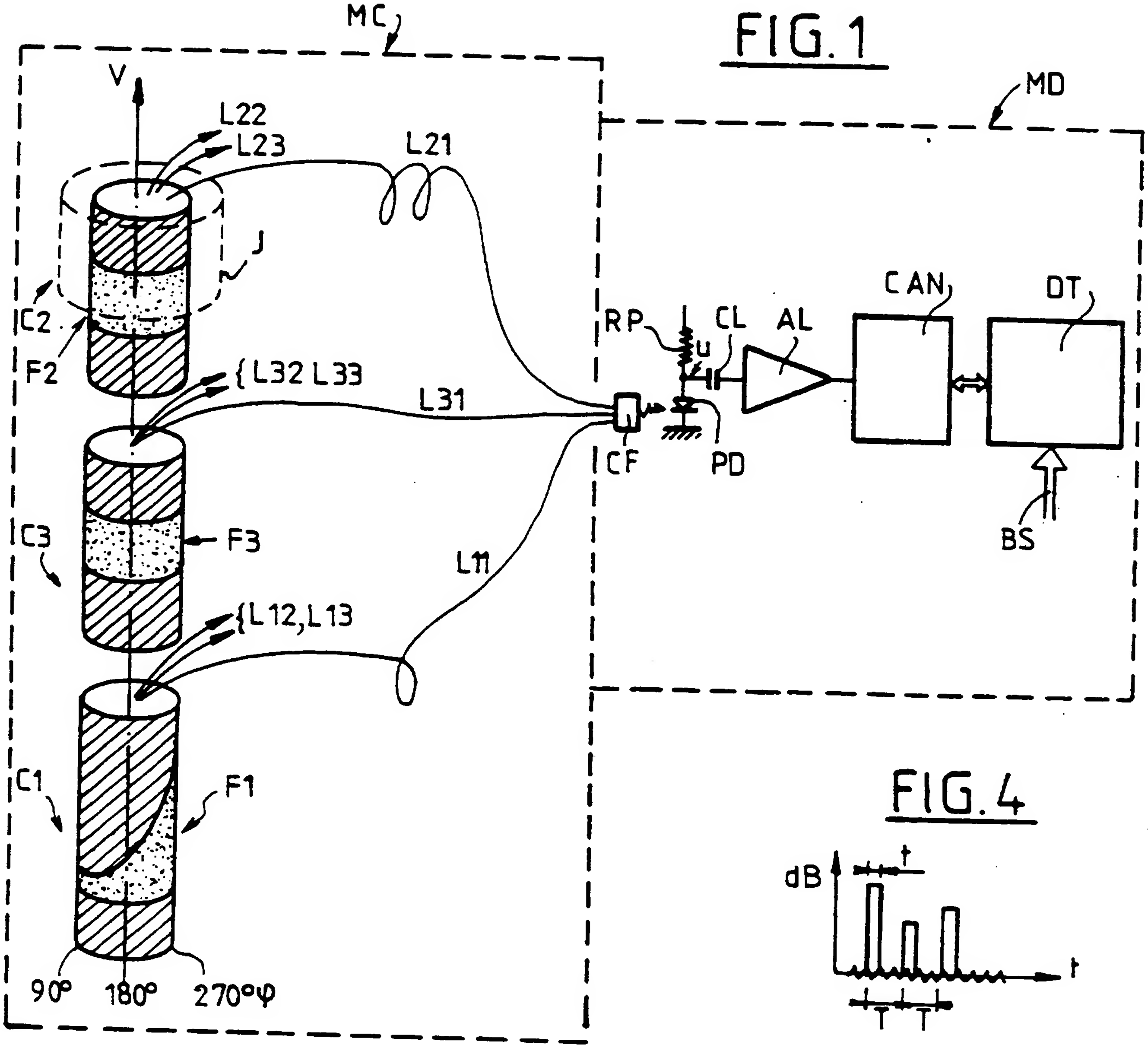


FIG. 4

FIG. 2

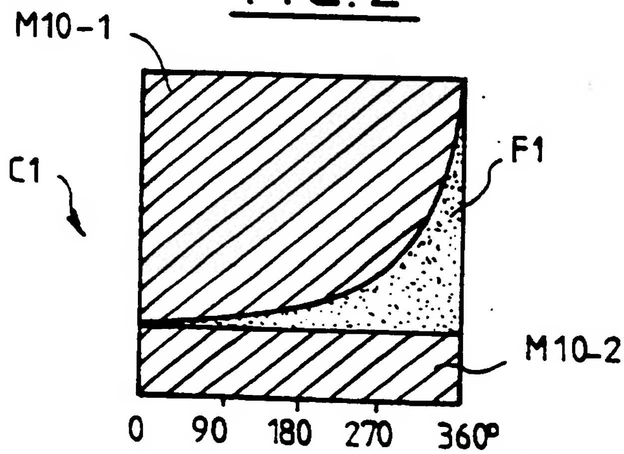


FIG. 3

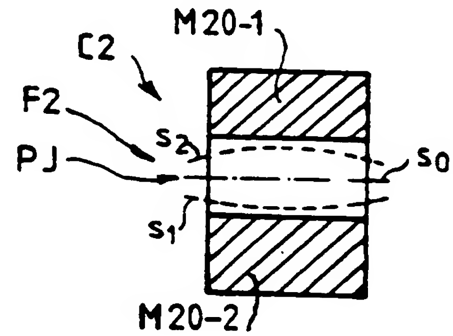


FIG. 5

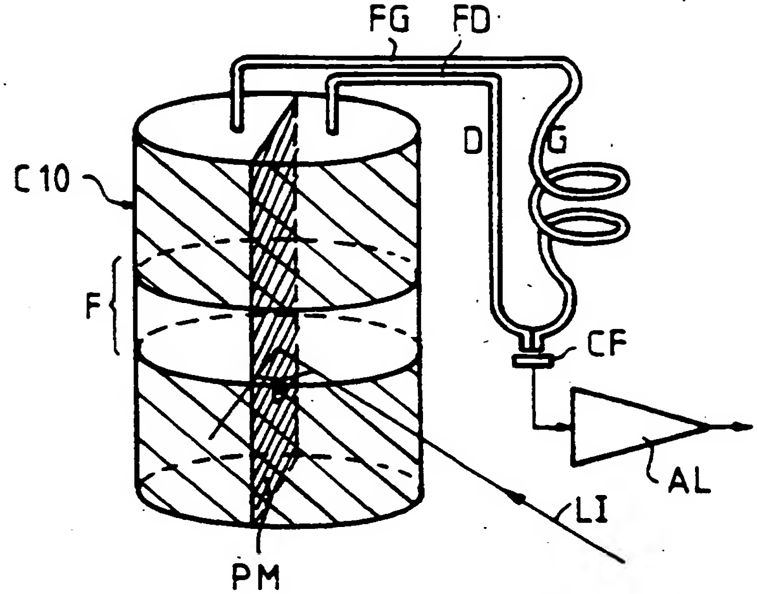


FIG. 6A

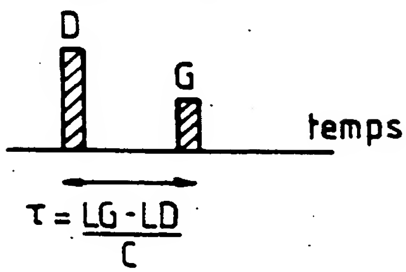


FIG. 6B

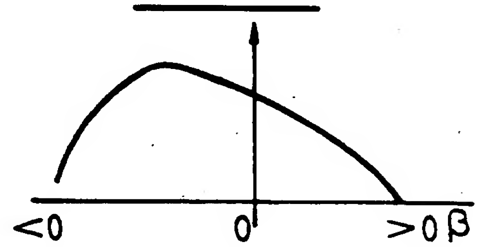


FIG. 7

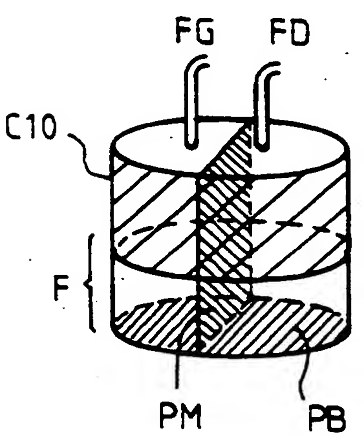
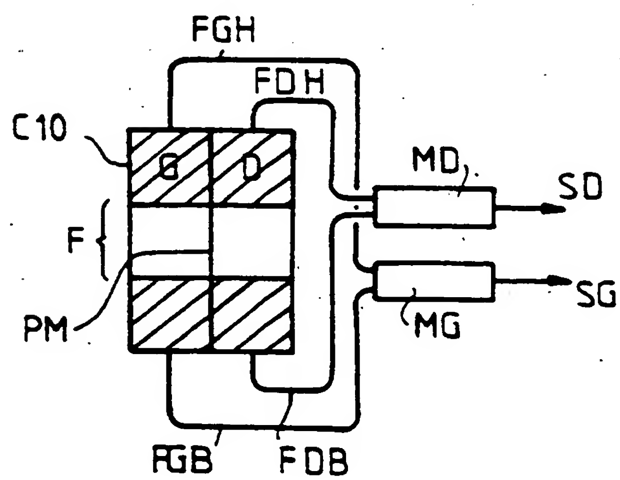


FIG. 8



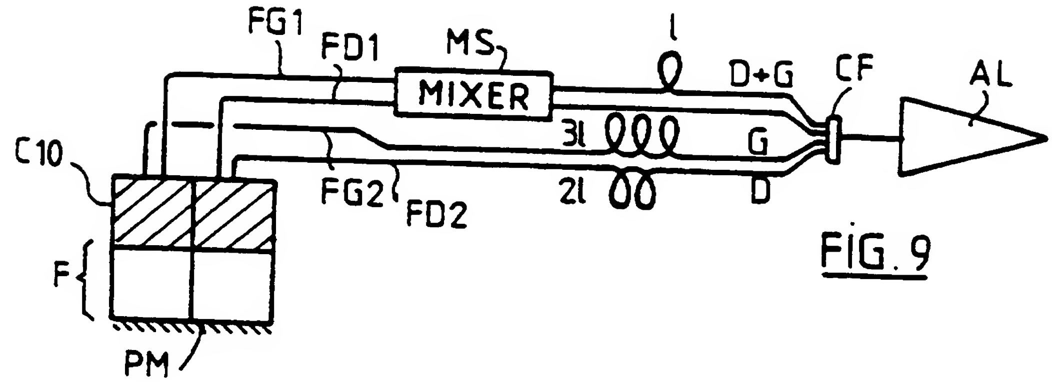


FIG. 9

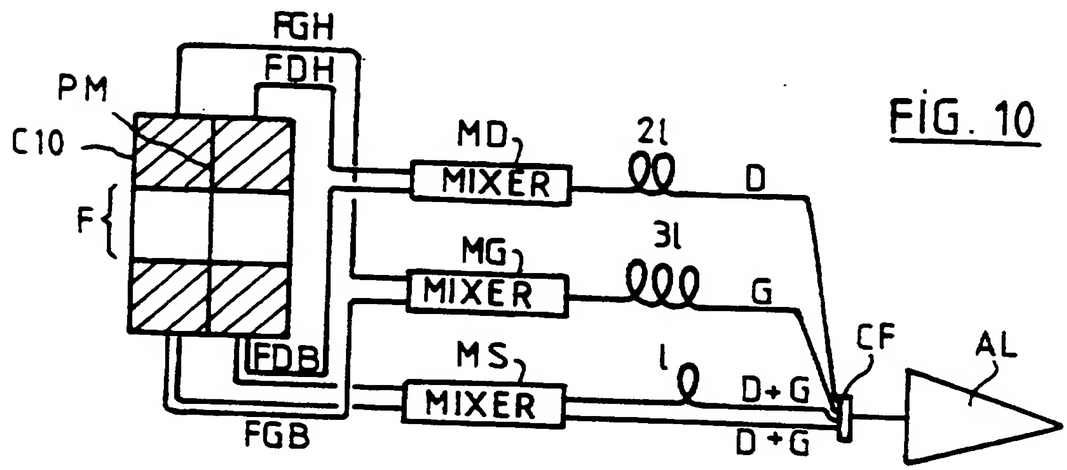


FIG. 10

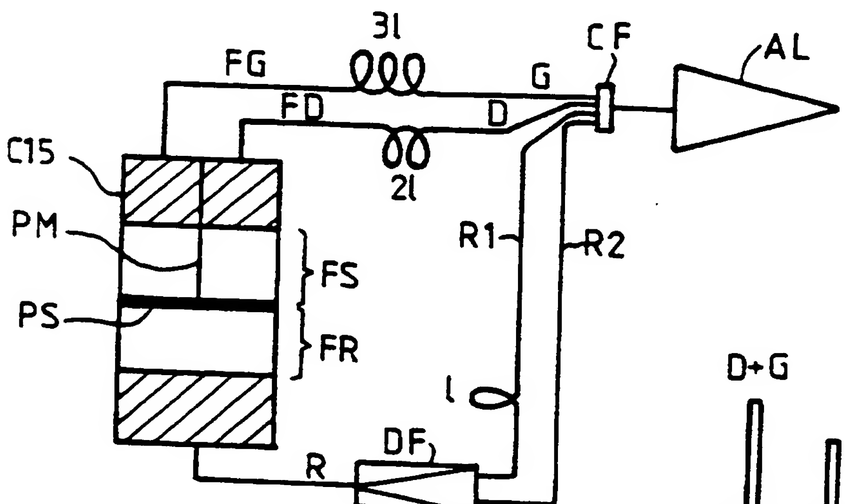


FIG. 11

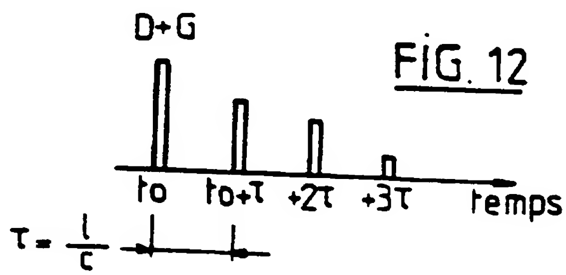


FIG. 12

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"A DETECTOR OF PULSES OF ELECTROMAGNETIC RADIATION, MORE PARTICULARLY LASER PULSES"

The invention relates to the detection of the arrival of laser pulses.

This is of interest more particularly for installation on board a tank, helicopter or aircraft for the purpose of detecting, and if possible identifying, the aiming of a laser-guided or -assisted weapon at the body carrying the device.

Existing systems are not entirely satisfactory, either because they are excessively simple (no indication of elevation, bearing incidence detection limited to presence in one of the four possible quadrants), or because the price of adequate precision is very complex equipment.

The primary object of the invention is to supply a sufficiently precise, but simple device able to operate in a waveband covering at least 0.3 to 3 micrometres.

The detector proposed is of the type comprising sensor means which are selective as regards the orientation of the incident beam, in bearing and/or in elevation, and which are connected to photodetector means. Note that the sensing function, which provides the selectivity of orientation but leaves the incident signal in electromagnetic form, is distinct from the detection function, which, by contrast, converts the electromagnetic signal into an electrical signal.

According to a first feature of the invention, the sensor means comprise at least one body of revolution, such as a cylinder, of material transparent but diffusing in volume, having a sensing window on its surface of revolution.

The height of this window may be constant or variable, for example with a monotonic variation, over its entire extent, so conferring on it sensitivity in bearing and/or in elevation.

Such a body, with a window of constant height, may act as a level reference.

The bodies are advantageously connected by connections such as optical fibres, having different transit times, to at least one common detector member per wavelength sub-band. Alternatively, however, there

may be one detector member per body; this gives greater dispersion of gain and therefore of absolute precision, but greater sensitivity. The separating power is not affected.

A detector member of this kind, whether common or not, comprises a photodetector which may be a photomultiplier, a PIN diode or an avalanche diode, depending on the sensitivity and waveband desired. This photodetector is coupled by a capacitor to a logarithmic amplifier, followed by an analog/digital coder processing means.

According to another, very useful feature of the invention, there are a plurality of optical fibre connections operating in different electromagnetic frequency sub-bands to be processed. The simplest arrangement is to provide one common detector member for each sub-band to be processed. Alternatively, however, a single common detector member may be provided for all the sub-bands, in which case the lengths of the fibres must all be different.

The role of the detector members in accordance with the invention is to compare the signals which are respectively responsive to the elevation and bearing with the contemporaneous reference signal. Preferably,

the common detector member will also measure the width of the pulses received.

The or each body embodying the invention may be made from glass with low absorption, for example borosilicates, preferably loaded with fine particles of titanium dioxide which render them diffusing. Their windows are defined, in the manner of a negative, by external metallisations.

For certain applications, the or each body may be covered with an electromagnetic band transposition layer, more particularly fluorescent, enabling the ultraviolet band to be transposed into the visible range to reduce the effective bandwidth of the optical fibres and detector.

In a variant of the invention, the angular sensitivity is obtained, at least in part, by internal metallisation of the body of revolution, dividing the latter into two portions subject to selective photodetection.

In one embodiment, the internal metallisation is plane and parallel to the axis of revolution of the body. Advantageously, the plane of metallisation passes through the axis of revolution of the body.

In practice, the body of revolution may be obtained by assembling two parts, for example with adhesive, with the metallisation interposed. The metallisation may be also applied before the sticking operation to one and/or the other of the two parts.

For detection, the two parts of the body are advantageously connected by at least two respective optical fibres to the photodetector means.

These two fibres may have a different transit time, while being connected to a common photodetector member.

In a useful variant of the invention, the body also has a terminal metallisation, on the opposite side from its connection to the optical fibres.

The peripheral sensing window may in that case be substantially adjacent to this terminal metallisation.

In a more advanced embodiment, a second body is joined to the first body, on the same side as its terminal metallisation, so giving a symmetrical arrangement.

The invention also provides for two sets of optical fibres, connected respectively to opposite ends of the body.

According to another feature of the invention, a reference signal may be obtained by adding the signals received in the two parts of the body.

Lastly, the invention may have recourse to the different variants described above for the other measurements by means of at least one other body.

Further features and advantages of the invention will be apparent from the ensuing detailed description and the accompanying drawings, in which:

Figure 1 illustrates one embodiment of a device in accordance with the invention;

Figure 2 shows a detail illustrating the structure of the body C1 in Figure 1;

Figure 3 is a detail illustrating diagrammatically the structure of the body C2 in Figure 1;

Figure 4 is a time diagram indicating a sequence of pulses obtained by means of the three bodies in Figure 1;

Figure 5 illustrates diagrammatically a second embodiment of the device in accordance with the invention;

Figures 6A and 6B are graphs relating to operation of the device shown in Figure 5;

Figure 7 illustrates diagrammatically a variant of the device in Figure 5;

Figure 8 illustrates diagrammatically another variant of the device in Figure 5;

Figure 9 represents an improvement on the variant in Figure 8;

Figure 10 represents an improvement on the variant shown in Figure 7;

Figure 11 illustrates another improvement of the variant in Figure 7; and

Figure 12 is a time diagram relating to the operation of the device shown in Figure 11.

The drawings have numerous aspects which are geometrical and/or certain in character. Consequently they may serve not only to clarify the ensuing description, but also to contribute to definition of the invention, where appropriate.

In Figure 1, the bodies C1 to C3 are three

cylinders of special glass (borosilicate) of which the transparency band extends, for example, from 0.3 to 3 micrometres. The glass is loaded with fine particles of titanium dioxide, also known as rutile, which impart to them a property of light diffusion in volume, or in other words renders them to some extent translucent.

These cylinders are arranged vertically (direction V). Their external surface is metallised, so as to leave exposed, on the external cylindrical surface of the bodies, only respective windows F1 to F3.

The cylinders are protected by a porthole (not shown), at least at the level of their windows.

In the case of the body C1 (Figure 2), the involute of the window is a curve which varies in geometrical progression as a function of the bearing angle $\underline{g}$. More particularly, since the law is continuous, the curve defining the width of the window has an exponential or power function form.

The other two bodies C2 and C3 have respective windows F2, F3 of which the height is constant irrespective of the bearing. The window F3 of the cylinder C3 is not masked. The window F2 of the cylinder C2, however, is masked at a distance depending on an annular skirt J, which projects over the glass

cylinder so as to obstruct approximately half of the window F2. The skirt is of course coaxial with the cylinder.

Figure 3 shows the shadow cast by the light arriving in different incidences of elevation s0, s1 and s2. The light arriving in the horizontal plane gives a cast shadow covering half of the window. Light arriving with a positive elevation gives a cast shadow reduced to the part between the curve s1 and the bottom of the window. Conversely, light arriving with a negative elevation s2 would give a cast shadow extending between the bottom of the window and the curve s2. The quantity of light reaching the window of the cylinder C2 is therefore a function of the elevation of the incident light pulse.

In the example described, the skirt J covers the upper portion of the window F2. For certain applications, it might cover the lower part of the same window.

A person skilled in the art will appreciate that:
the body C3 may act as an omnidirectional bearing reference, giving a power P0;
the body C1 gives a power which varies in geometrical progression with the bearing angle, this power being designated P1;

the body C2 gives a power which varies according to a monotonic function of the angle of elevation, this power being designated P2.

From each of the cylinders C1 to C3, an optical fibre L11 to L31 absorbs energy which is therefore proportional to the power diffused in this cylinder. The lengths of the optical fibres are different, so that the light pulses received simultaneously by each of the cylinders are retarded differently, by a known time which is proportional to the difference in length of the optical fibres.

A member CF combines the outputs from the optical fibres L11 to L31, by adding. The resulting added signal is applied to a quadratic light detector PD, for example an avalanche diode, advantageously polarised by means of a resistor RP.

At the output from the diode PD, the electrical signal available is a direct-current voltage U0 which corresponds to the polarisation of the diode and to the permanent ambient light. On arrival of a light pulse of duration t, associated with a given bearing and elevation q and s, the photodetector PD will register three pulses of duration t at intervals T, T being the difference in transit time on the various optical fibres

(the difference being assumed to be the same for all fibres).

It will be assumed first that this time difference is much greater than the duration of the laser pulses.

The output voltage U from the diode PD is then expressed as the sum of the term UO, three terms linked to the respective contributions of the three bodies, and a final term N(t) which is the noise produced by the instantaneous current in the diode.

The capacitor CL eliminates the constant term UO.

It is connected to a logarithmic amplifier AL, followed by an analog/digital coder CAN and by a processing device DT coupled to a bus BS.

At the output from the logarithmic amplifier AL the signal obtained, in the absence of incident laser pulses, represents the noise NO(t).

During the first pulse, coming from the body C3, a signal U3 is obtained which is the sum of a term A, the logarithm of the power PO and a noise term Na(t).

During the presence of the second pulse, coming from the body C1, the signal U1 is equal to the sum of a term

B, the logarithm of the power PO, a factor proportional to the bearing angle, and a noise term Nb(t).

During the presence of the third pulse, which comes from the body C2, the signal U2 is equal to the sum of a term C, the logarithm of the power PO, another factor, this time proportional to the logarithm of the elevation function given by the body C2, and lastly a noise term Nc(t).

By balancing losses or by correction, the terms A, B and C can be made equal.

The difference between the signals U1 and U3 then gives a voltage representing the bearing angle, assuming that the sum of the noises is negligible.

On the same hypothesis, the difference between the voltages U2 and U3 supplies an indication of elevation.

A person skilled in the art will appreciate that after digitisation in the coder CAN, the processing device DT is in a position to specify the direction of the incident laser pulse. It can even measure its duration.

By way of example, it may be stated that the power function for the body C1 may be in the form $3^{g/90^{o}}$.

This gives a level variation as a function of the bearing which is approximately $\pm$ 10 dB for $\pm$ 90° relative to the reference 180°. At present, at the output from a logarithmic amplifier, a level variation of 0.25 dB can be detected; the other errors, moreover, are of the same order of magnitude. The accuracy obtained for the bearing measurement is greater than 5°, in its mean square value.

The variation in level as a function of the angle of elevation s may be obtained with a precision of the same order of magnitude, by varying the diameter of the skirt J of the body C2.

It was assumed above that the duration t of the incident laser pulses was less than the time interval T corresponding to the differences in length between the optical fibres. In the opposite case, in which t is greater than T, the system still operates, but systematic correction of the measuring result is necessary. However, precision is less, as those skilled in the art will understand.

As Figure 1 shows, other optical fibre connections (respectively L12, L13, L22, L23, L32, L33) may be run from each of the bodies C1 to C3.

These optical fibres are equipped in a known manner with filtering instruments, so that each optical fibre transmits the signal only for part of the spectrum of incident electromagnetic signals.

In other words, each set of optical fibres, for example L12, L22, L32, corresponds to a particular sub-band, in the domain of possible incident electromagnetic signals.

By suitably varying the time lags at the exits from the fibres, the same detector module MD can be used for all of the fibres, if the bandwidth of the detector permits.

It is preferred at present to provide a plurality of detector modules MD, each being used in common by a single set of fibres such as L11, L21 and L31, or L12, L22 and L32.

Conversely, if it is desirable to process the entire possible range of incident electromagnetic signals with a single device, the cylinders C1 to C3 may be covered with a thin layer of a fluorescent substance transposing the ultraviolet bands towards the usable bands of the detectors operating towards the red and infrared.

Other currently preferred embodiments of the invention will now be described.

In Figure 5, a body C10 comprises two half cylinders of special glass (borosilicate), of which the transparency band extends, for example, from 0.3 to 3 micrometres. The glass is loaded with fine particles of titanium dioxide, also known as rutile, which confers on it a property of light diffusion in volume.

Between the two half cylinders a metallised surface PM is placed, this being as perfectly reflective as possible for the wavelengths to be detected.

Externally, the cylinder C10 is metallised on its cylindrical surface, except in a window F which is here defined by two horizontal planes.

A lefthand and a righthand portion are thus defined in the body C10. The two portions are coupled to respective optical fibres FG and FD, leading to an opto-electronic detector CF followed by a logarithmic amplifier AL. Otherwise the signals can be utilised as described with reference to Figures 1 to 4.

As before, the lefthand fibre FG may be made longer than the righthand fibre FD, so that their respective signals arrive at different instants at the detector CF

and amplifier AL, as illustrated in Figure 6A. The time lag equals the difference between the fibre lengths divided by the velocity of propagation of the electromagnetic waves.

The quantities of light respectively diffused inside the two halves of the body C10 depend on the bearing angle of the incident laser beam LI.

When this beam arrives perpendicular to the surface PM from the right, the righthand fibre FD will register an intense signal, whereas the lefthand fibre FG will not register any signal diffused in volume inside the body C10, in its lefthand portion. The situation is reversed when the incident light arrives perpendicular to the surface PM from the left.

In intermediate situations, the proportion of signals respectively registered by the fibres FG and FD is linked to the bearing angle of the incident light beam LI.

The comparison of the light signals sensed, after conversion into electrical form, therefore makes it possible to determine the bearing angle.

Figure 6B illustrates the sensitivity of the system to the angle of elevation.

For negative elevations, allowing for the vertical position of the body in Figure 5, a considerable quantity of light goes towards the optical fibres, since the direction of the light has a component oriented towards the optical fibres. For positive elevations, on the other hand, the light is directed towards the bottom or lower part of the body C10. A smaller proportion of light will therefore be transmitted to the optical fibres.

It is conceivable that this might be utilised to give crude elevation data, while maintaining the bearing sensitivity, since the latter depends only on the ratio between the light intensities registered by the two halves of the body C10 and not on their absolute values.

For numerous applications, however, this asymmetry in elevation is inconvenient, to the extent that it reduces the sensitivity of bearing angle measurement for positive angles of elevation, seeing that the fibres are placed on the upper part of the cylindrical bar.

Figure 7 illustrates a first way to reduce this asymmetry.

Instead of being situated in the intermediate portion of the body of revolution C10, as in Figure 5, the window F is here substantially adjacent to the

bottom of this body, which is equipped with a metallised surface PB.

The incident beams with a positive angle of elevation are then reflected on this surface PB, which brings them back towards the upper optical fibres with practically the same transmissivity as for negative angles of elevation.

A different way to proceed is illustrated in Figure 8. The window F here remains in its intermediate position in the body C10. However, two sets of optical fibres are provided, the higher fibres having the suffix H and the bottom fibres the suffix B. A mixer/adder MD finds the sum of the signals registered by the righthand fibres, and another mixer MG does the same for the lefthand fibres. This finally gives signals SD and SG of which the dependence in elevation is practically zero. The mixers MD and MG can operate either in the optical part or the electrical part of the system.

As in the first embodiment, numerous variants can be envisaged for the processing of the signal, from the instant at which it is sensed in the body such as C10. Also, different types of body may be provided, one disposed for bearing measurement and the other for elevation measurement, while retaining the third reference body described above. More particularly, at

least one of the angle-sensitive bodies in Figures 1 to 4 may be replaced with a body as in subsequent Figures (especially 5 to 8). Also, the effects of a window of variable height and internal metallisation could be combined to give the angular sensitivity.

At the processing level, processing can be effected in parallel fashion, that is, with separate channels for each fibre, or in series, with common detector members, provided that the fibres are of different lengths so that they transmit their signals at different instants.

In the latter case a difficulty is encountered, since the weakening of the signal in the fibres is proportional to distance, and also this weakening varies according to the wavelength.

Figure 9 illustrates a way of overcoming this problem as regards the weakening as a function of the length of the fibres.

The lefthand half of the body C10 is equipped in its upper part with two fibres FG1 and FG2. The same applies to its righthand half, which has two fibres FD1 and FD2.

An optical mixer MS obtains the sum of the signals from the two fibres FD1 and FG1. Downstream, the fibre

FG1 is extended by a length l. The fibre FD2, in turn, is extended by a length 2l, and the fibre FG2 by a length 3l. As Figure 12 shows, the signals from the four fibres arrive at the sensor CF in succession, separated by a time interval equal to the quotient of the increment of length l divided by the velocity of propagation of the electromagnetic waves.

Comparison of the first two pulses makes it possible to measure the weakening of the signal on the increment of length l.

By comparing the last two pulses, an error signal is obtained, this signal being reduced by the weakening on the increment of length l. Note that these signals are logarithmic, as is the weakening. Adding the two results of these two comparisons gives the logarithm of the ratio between the signals obtained in the righthand and lefthand portions of the body C10.

The embodiment in Figure 10 does the same, but in the case of the body shown in Figure 8. To compare the processing in Figure 10 with that in Figure 9, it need merely be stated that the mixer MS supplies a total signal, while the mixers MG and MD supply two sub-totals respectively relating to the righthand and lefthand portions of the body C10.

Another variant is illustrated in Figure 11.

A cylinder of the same diameter as the cylinder in Figure 7, but without the metallised diametrical surface, is stuck to the metallised bottom of the cylinder from Figure 7.

The body C15 then fulfils two functions, since it has a signal window FS at the top and a reference window FR at the bottom.

The signal due to the incident beam entering through the reference window FR has a light power independent of the bearing angle. After diffraction inside the diffusing volume of the body, this light power is collected by the fibre R, which supplies a divider DF. The latter in turn breaks it down into two fibres R1 and R2, the first being longer than the second by a length increment <u>l</u>.

The upper two fibres FD and FG have length increments 2<u>l</u> and 3<u>l</u> respectively.

The signals then obtained, in time, are as in Figure 12, but with a different definition from that described with reference to Figure 9.

None the less the weakening due to the length increment l can be determined, for the incident wavelength concerned. It is therefore possible, as before, to correct the effective signal from the fibres FG and FD, before it is processed by the logarithmic amplifier.

The processing operations downstream of the logarithmic amplifier are the same as in Figures 1 to 4.

As stated above, the weakening in the fibres also varies as a function of the incident laser wavelength.

In the embodiments shown in Figures 9 to 11 the attenuation measurement is related to the known length increment l. From this attenuation measurement the wavelength can be deduced. Any ambiguities can be eliminated, since the usual wavelength ranges of the lasers concerned are known.

It will be noted that the device in accordance with the invention is particularly suitable for the applications intended, in which the most important factor is the accuracy of the angle measurements.

It also determines the frequency band, the pulse width and the absolute level. However, the latter is an unsatisfactory parameter, as it fluctuates widely.

It should be noted also that the system in accordance with the invention is very compact, so that it can be installed almost anywhere, and particularly in all land combat vehicles and all aircraft.

A vehicle so equipped is able, by co-relating the direction of arrival, the pulse width, the wavelength sub-band and the level, to determine the repetition period of the pulses and, if possible, to identify the threat.

The invention is not restricted to the embodiment described. It should be noted that the diameter and length of the bodies (C) are optimised as a function of the aperture angle of the optical fibres (L). Also, the density of diffusing particles is optimised as a function of the diameter of the bodies (C); in particular, it decreases when the diameter of the body (C) increases.

CLAIMS

1. A detector of pulses of electromagnetic radiation, more particularly laser pulses, comprising sensor means (MC) which are responsive to the orientation of the incident beam, in bearing and/or in elevation, and which are connected to photodetector means (MD), characterised in that the sensor means comprise at least one body of revolution (C1) of transparent material which is diffusing in volume, for the electromagnetic radiation, having a sensing window on its surface of revolution.

2. A detector as claimed in claim 1, characterised in that the sensing window (F1) has a monotonic variation, over its entire extent, as a function of the angle, conferring angular sensitivity on the body, in bearing and/or in elevation.

3. A detector as claimed in claim 1, characterised in that the involute of the window (F1) varies as a power function of the angle.

4. A detector as claimed in claim 1 or 3, characterised in that the sensor means comprises at least one other body of revolution (C2, C3), oriented vertically and having a sensing window (F2, F3) of constant height.

5. A detector as claimed in claim 4, characterised in that the sensor means comprise two bodies of revolution (C2, C3) with windows of constant height (F2, F3), one not masked (C3) serving as a reference whereas the other (C2), masked at a distance by a horizontal mask, provides an indication of elevation.

6. A detector as claimed in claim 4 or 5, characterised in that the bodies (C1, C2, C3) are connected by connections (L11, L21, L31), having different transit times, to at least one common detector member (MD).

7. A detector as claimed in claim 6, characterised in that the common detector member (MD) comprises a photodiode (PD), coupled by a capacitor (CL) to a logarithmic amplifier (AL), followed by an analog/digital coder (CAN) and processing means (DT).

8. A detector as claimed in claim 6 or 7, characterised in that it comprises a plurality of optical fibre connections (L11, L12, L13; L21, L22, L23; L31, L32, L33), operating in different electromagnetic frequency sub-bands, and all of different lengths, or leading to different common detector members.

9. A detector as claimed in any one of claims 6 to 8, characterised in that the common detector member (MD) compares the signals which are respectively responsive to the elevation and bearing with the contemporaneous reference signal.

10. A detector as claimed in claim 9, characterised in that the common detector member (MD) also measures the width of the pulses received.

11. A detector as claimed in any one of the preceding claims, characterised in that the or each body (C) is of glass highly transparent in the band used, preferably loaded with fine particles of titanium dioxide, the or each window being defined, in the manner of a negative, by external metallisation.

12. A detector as claimed in any one of the preceding claims, characterised in that the or each body (C) is covered with an electromagnetic band transposition layer.

13. A detector as claimed in any one of the preceding claims, characterised in that it is protected by a porthole to prevent the deposition of particles on the window of the or each body (C).

14. A detector as claimed in claim 8, characterised in that the diameter and length of the or each body (C) are optimised as a function of the aperture angle of the optical fibres (L).

15. A detector as claimed in claim 11, characterised in that the density of diffusing particles is optimised as a function of the diameter of the or each body (C), in particular decreasing for an increase in the diameter of the body (C).

16. A detector as claimed in any one of claims 1 to 5, characterised in that angular sensitivity is obtained, at least in part, by internal metallisation of the body of revolution, dividing the latter into two portions subject to selective photodetection.

17. A detector as claimed in claim 16, characterised in that the internal metallisation is plane and parallel to the axis of revolution of the body.

18. A detector as claimed in claim 17, characterised in that the plane of metallisation passes through the axis of revolution of the body (C1).

19. A detector as claimed in any one of claims 16 to 18, characterised in that the body of revolution is

an assembly of two parts with the metallisation interposed.

20. A detector as claimed in any one of claims 16 to 19, characterised in that the two parts of the body are connected respectively by two optical fibres to the photodetector means.

21. A detector as claimed in claim 20, characterised in that the two fibres have a different transit time, and are connected to a common photodetector member.

22. A detector as claimed in claim 20 or 21, characterised in that the two two parts of the body are connected also by two other fibres to the photodetector means, and the differences in length between these other two fibres and the first, which are known, permit compensation of the weakening of the signals as a function of the length of the fibres.

23. A detector as claimed in claim 22, characterised in that the photodetector means are also arranged to evaluate the wavelength of the incident signal, from the differences in attenuation between the said other optical fibres and the first fibres.

24. A detector as claimed in claim 20, characterised in that the body also has a terminal metallisation, on the opposite side from its connection to the optical fibres.

25. A detector as claimed in claim 24, characterised in that the window is substantially adjacent to this terminal metallisation.

26. A detector as claimed in claim 24 or 25, characterised in that a second body is joined to the first body, on the same side as its terminal metallisation.

27. A detector as claimed in any one of claims 20 to 23, characterised in that there are two sets of optical fibres connected respectively to opposite ends of the body.

28. A detector as claimed in any one of claims 16 to 27, characterised in that a level reference signal is obtained by adding the signals received in the two parts of the body.

29. A detector as claimed in any one of claims 16 to 28, characterised in that at least one other body is provided, for measurement responsive to the other one of the angles of bearing and elevation.

Amendments to the claims have been filed as follows

1. A detector of pulses of electromagnetic radiation, comprising capture means (MC) which are responsive to the orientation of the incident beam, in bearing and/or in elevation, and which are connected to photodetector means (MD), characterised in that the capture means comprise at least one body of revolution (C1) of transparent material which is diffusing in volume, for the electromagnetic radiation, having a capture window on its surface of revolution.

2. A detector as claimed in claim 1, characterised in that the capture window (F1) has a monotonic variation, over its entire extent, as a function of the angle, conferring angular sensitivity on the body, in bearing and/or in elevation.

3. A detector as claimed in claim 1, characterised in that the involute of the window (F1) varies as a power function of the angle.

4. A detector as claimed in claim 1 or 3, characterised in that the capture means comprises at least one other body of revolution (C2, C3), oriented vertically and having a capture window (F2, F3) of constant height.

5. A detector as claimed in claim 4, characterised in that the capture means comprise two bodies of revolution (C2, C3) with capture windows of constant height (F2, F3), one not masked (C3) serving as a reference whereas the other (C2), masked at a distance by a horizontal mask, provides an indication of elevation.

6. A detector as claimed in claim 4 or 5, characterised in that the bodies (C1, C2, C3) are connected by connections (L11, L21, L31), having different transit times, to at least one common detector member (MD).

7. A detector as claimed in claim 6, characterised in that the common detector member (MD) comprises a photodiode (PD), coupled by a capacitor (CL) to a logarithmic amplifier (AL), followed by an analog/digital coder (CAN) and processing means (DT).

8. A detector as claimed in claim 6 or 7, characterised in that it comprises a plurality of optical fibre connections (L11, L12, L13; L21, L22, L23; L31, L32, L33), operating in different electromagnetic frequency sub-bands, and all of different lengths, or leading to different common detector members.

9. A detector as claimed in any one of claims 6 to 8, characterised in that the common detector member (MD) compares the signals which are respectively responsive to the elevation and bearing with the contemporaneous reference signal.

10. A detector as claimed in claim 9, characterised in that the common detector member (MD) also measures the width of the pulses received.

11. A detector as claimed in any one of the preceding claims, characterised in that the or each body (C) is of glass highly transparent in the band used, preferably loaded with fine particles of titanium dioxide, the or each capture window being defined, in the manner of a negative, by external metallisation.

12. A detector as claimed in any one of the preceding claims, characterised in that the or each body (C) is covered with an electromagnetic band transposition layer.

13. A detector as claimed in any one of the preceding claims, characterised in that it is protected by a porthole to prevent the deposition of particles on the window of the or each body (C).

14. A detector as claimed in claim 8, characterised in that the diameter and length of the or each body (C) are optimised as a function of the aperture angle of the optical fibres (L).

15. A detector as claimed in claim 11, characterised in that the density of diffusing particles is optimised as a function of the diameter of the or each body (C), in particular decreasing for an increase in the diameter of the body (C).

16. A detector as claimed in any one of claims 1 to 5, characterised in that angular sensitivity is obtained, at least in part, by internal metallisation of the body of revolution, dividing the latter into two portions subject to selective photodetection.

17. A detector as claimed in claim 16, characterised in that the internal metallisation is plane and parallel to the axis of revolution of the body.

18. A detector as claimed in claim 17, characterised in that the plane of metallisation passes through the axis of revolution of the body (C1).

19. A detector as claimed in any one of claims 16 to 18, characterised in that the body of revolution is

an assembly of two parts with the metallisation interposed.

20. A detector as claimed in any one of claims 16 to 19, characterised in that the two parts of the body are connected respectively by two optical fibres to the photodetector means.

21. A detector as claimed in claim 20, characterised in that the two fibres have a different transit time, and are connected to a common photodetector member.

22. A detector as claimed in claim 20 or 21, characterised in that the two parts of the body are connected also by two other fibres to the photodetector means, and in that known differences in length between these other two fibres and the first two fibres permit compensation of the weakening of the signals as a function of the length of the fibres.

23. A detector as claimed in claim 22, characterised in that the photodetector means are also arranged to evaluate the wavelength of the incident signal, from the differences in attenuation between the said other two optical fibres and the first two fibres.

24. A detector as claimed in claim 20, characterised in that the body also has a terminal metallisation, on the opposite side from its connection to the optical fibres.

25. A detector as claimed in claim 24, characterised in that the capture window is substantially adjacent to this terminal metallisation.

26. A detector as claimed in claim 24 or 25, characterised in that a second body is joined to the first body, on the same side as its terminal metallisation.

27. A detector as claimed in any one of claims 20 to 23, characterised in that there are two sets of optical fibres connected respectively to opposite ends of the body.

28. A detector as claimed in any one of claims 16 to 27, characterised in that a level reference signal is obtained by adding the signals received in the two parts of the body.

29. A detector as claimed in any one of claims 16 to 28, characterised in that at least one other body is provided, for measurement responsive to the other one of the angles of bearing and elevation.

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PATENTS ACT 1977
EXAMINER'S REPO[redacted]TO THE COMPTROLLER
UNDE[redacted]TION 17(5)
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FIELD OF SEARCH: The search has been conducted through the relevant published UK patent specifications and applications, and applications published under the European Patent Convention and the Patent Co-operation Treaty (and such other documents as may be mentioned below) in the following subject-matter areas:-

UK Classification H4D (DLFA)

(Collections other than UK, EP & PCT:) Selected US specifications in IPC sub-class G01S

DOCUMENTS IDENTIFIED BY THE EXAMINER (NB In accordance with Section 17(5), the list of documents below may include only those considered by the examiner to be the most relevant of those lying within the field (and extent) of search)

Category	Identity of document and relevant passages	Relevant to claim(s)
	None	

CATEGORY OF CITED DOCUMENTS

- X relevant if taken alone
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Search examiner T Berry

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